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Towards sideband-separation for ALMA's highest bands

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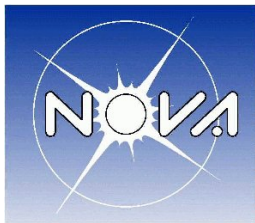
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Towards sideband-separation for ALMA's highest bands



NOVA Sub-mm
Instrumentation
Group

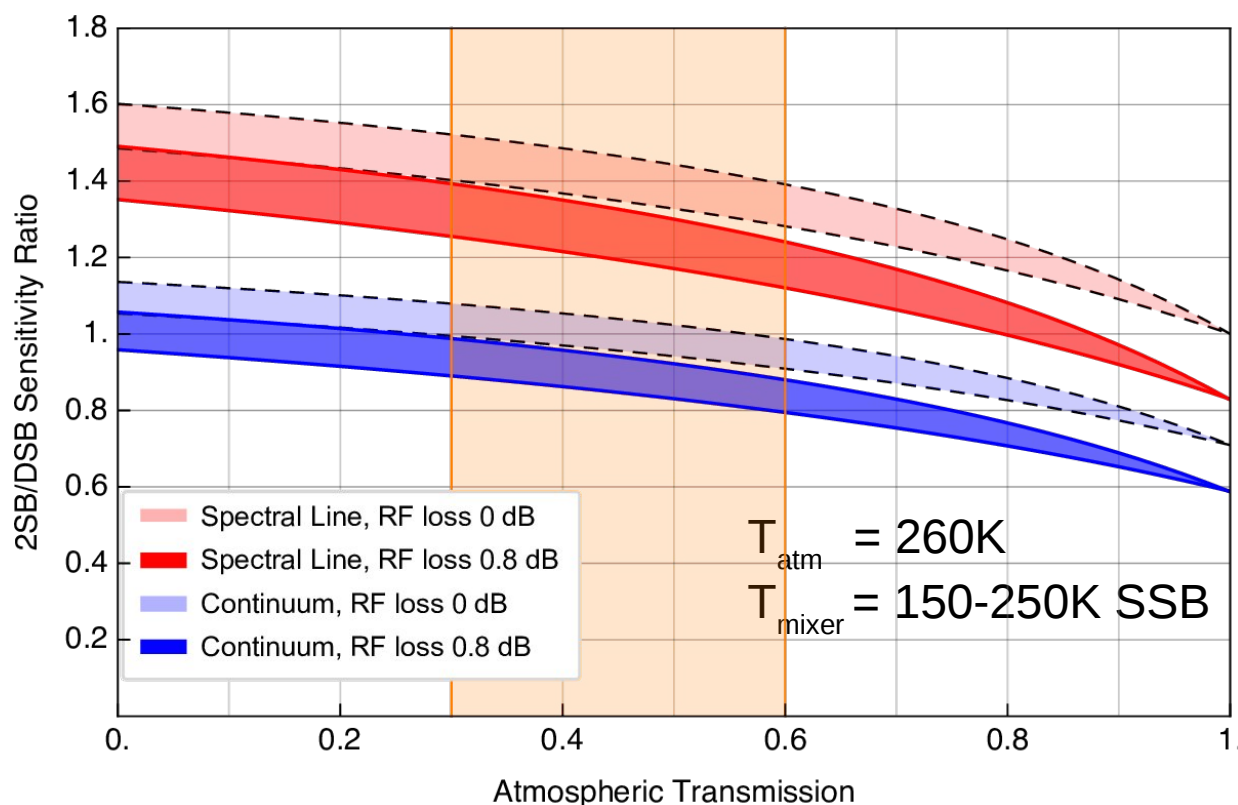


kapteyn astronomical
institute

Ronald Hesper
Andrey Khudchenko
Andrey Baryshev
Jan Barkhof
Mariëlle Bekema
Rob de Haan-Stijkel

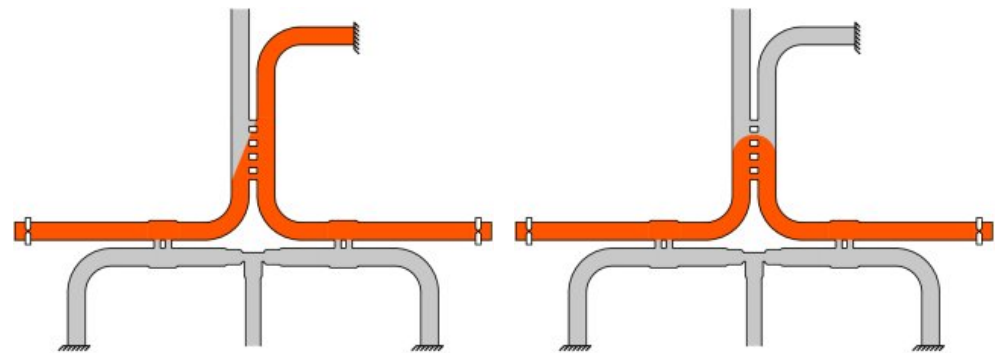
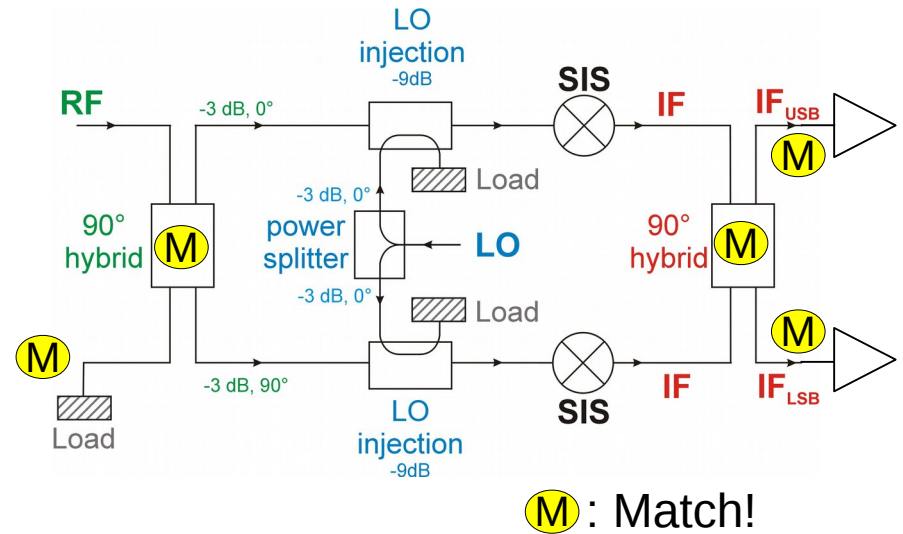
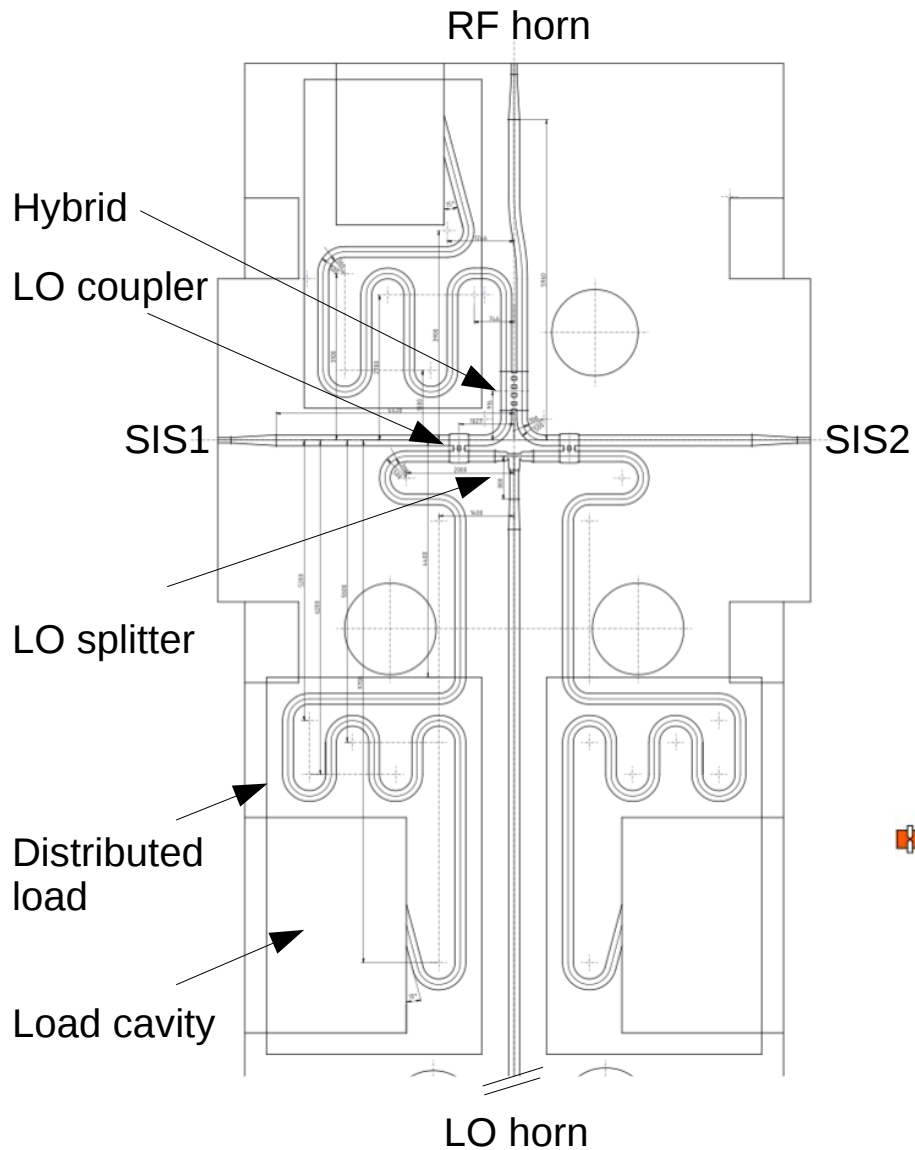
Benefits of sideband-separation

1: Improved spectral line sensitivity for atmosphere-limited bands



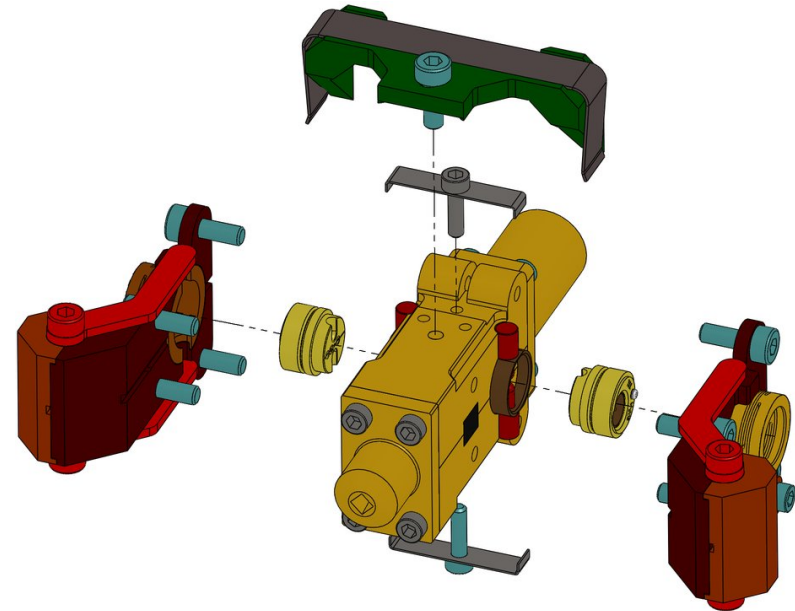
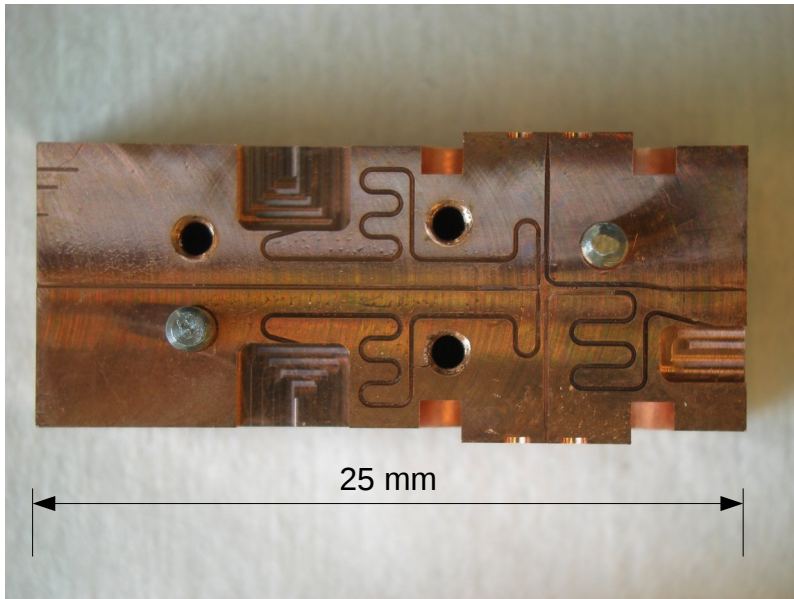
2: Avoiding line-confusion; can partially be solved in the correlator, at the cost of longer integration time

An optimized Band 9 2SB mixer



Key: avoid multiple reflection paths

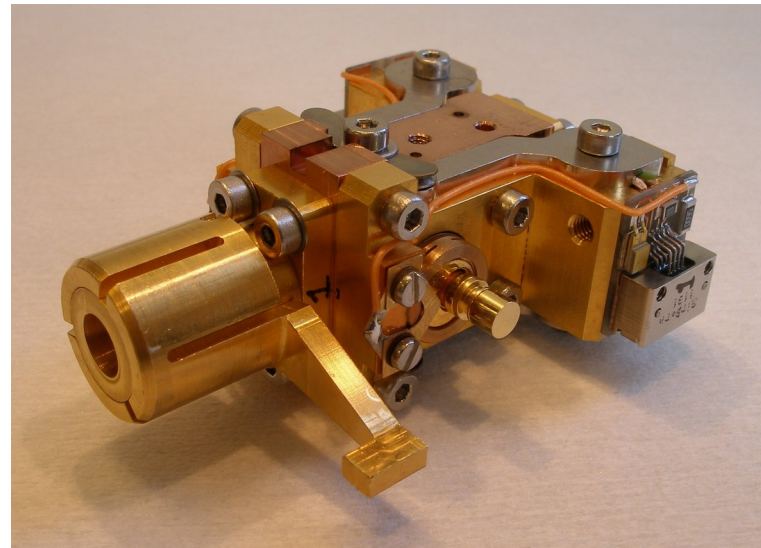
Modularity



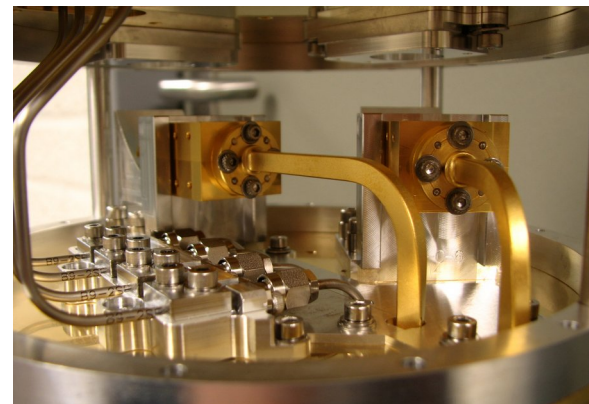
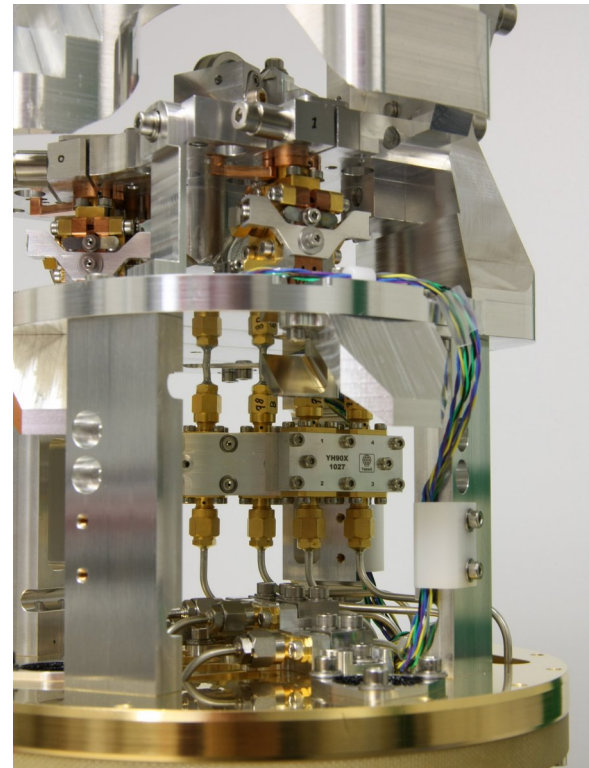
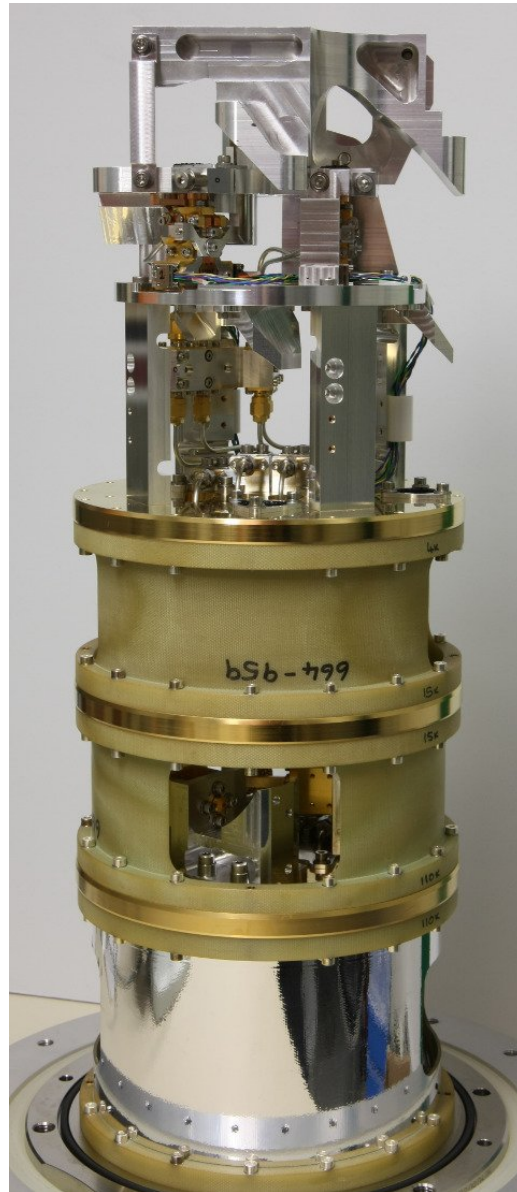
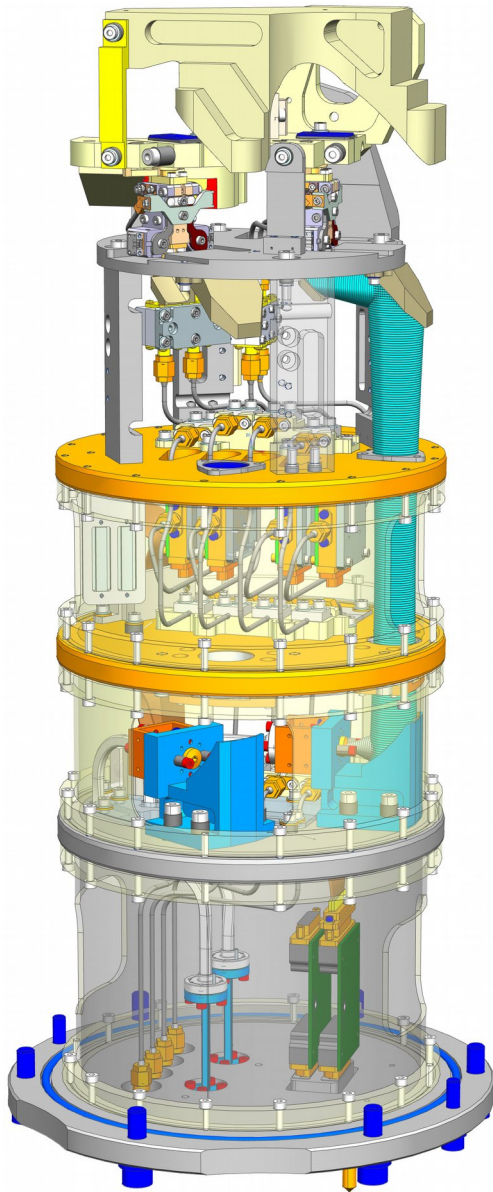
Mixer is modular

- Less critical for manufacturing
- Testable at component-level
- Mix & Match of SIS devices

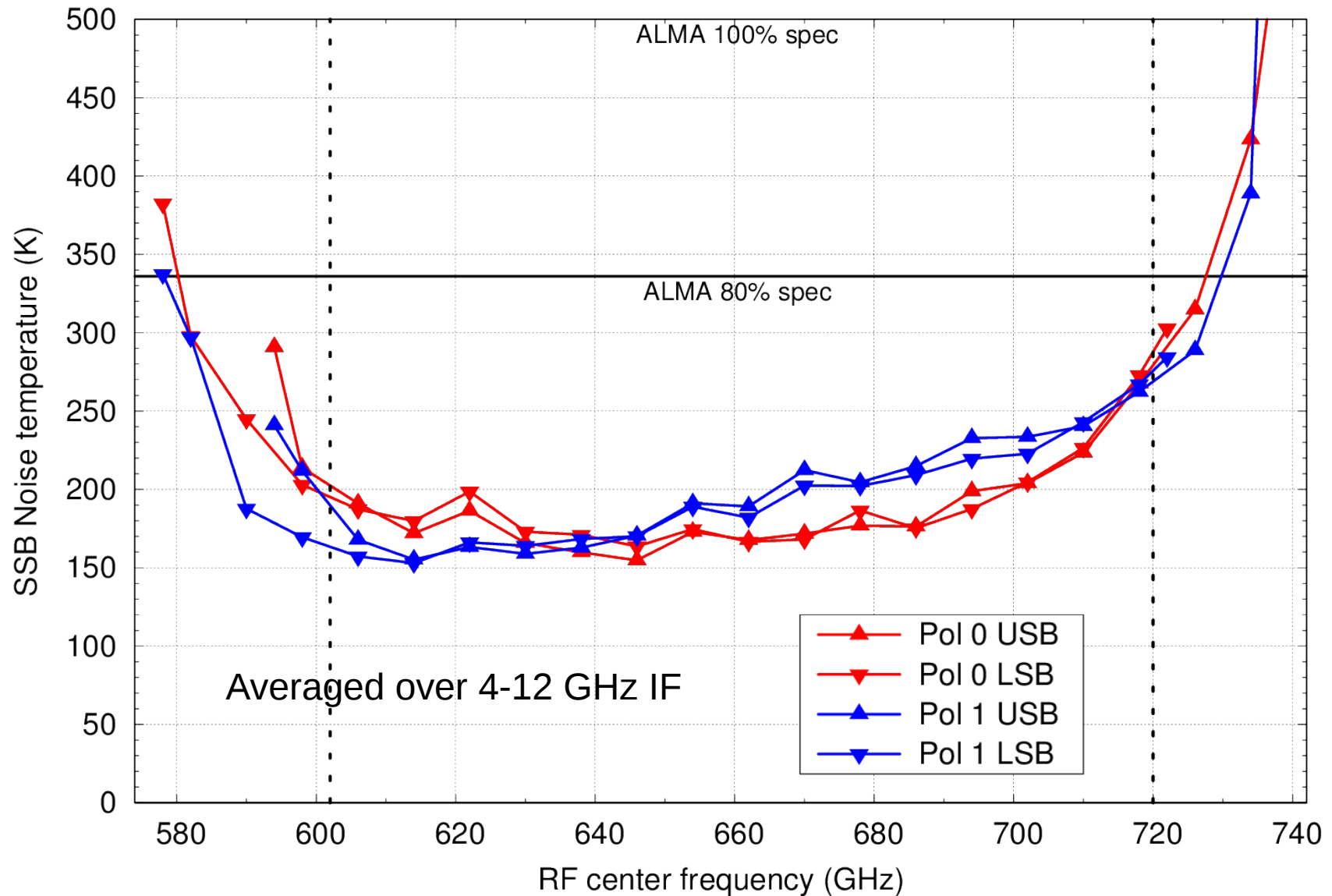
Mixer backpieces are identical to existing Band 9 DSB ones



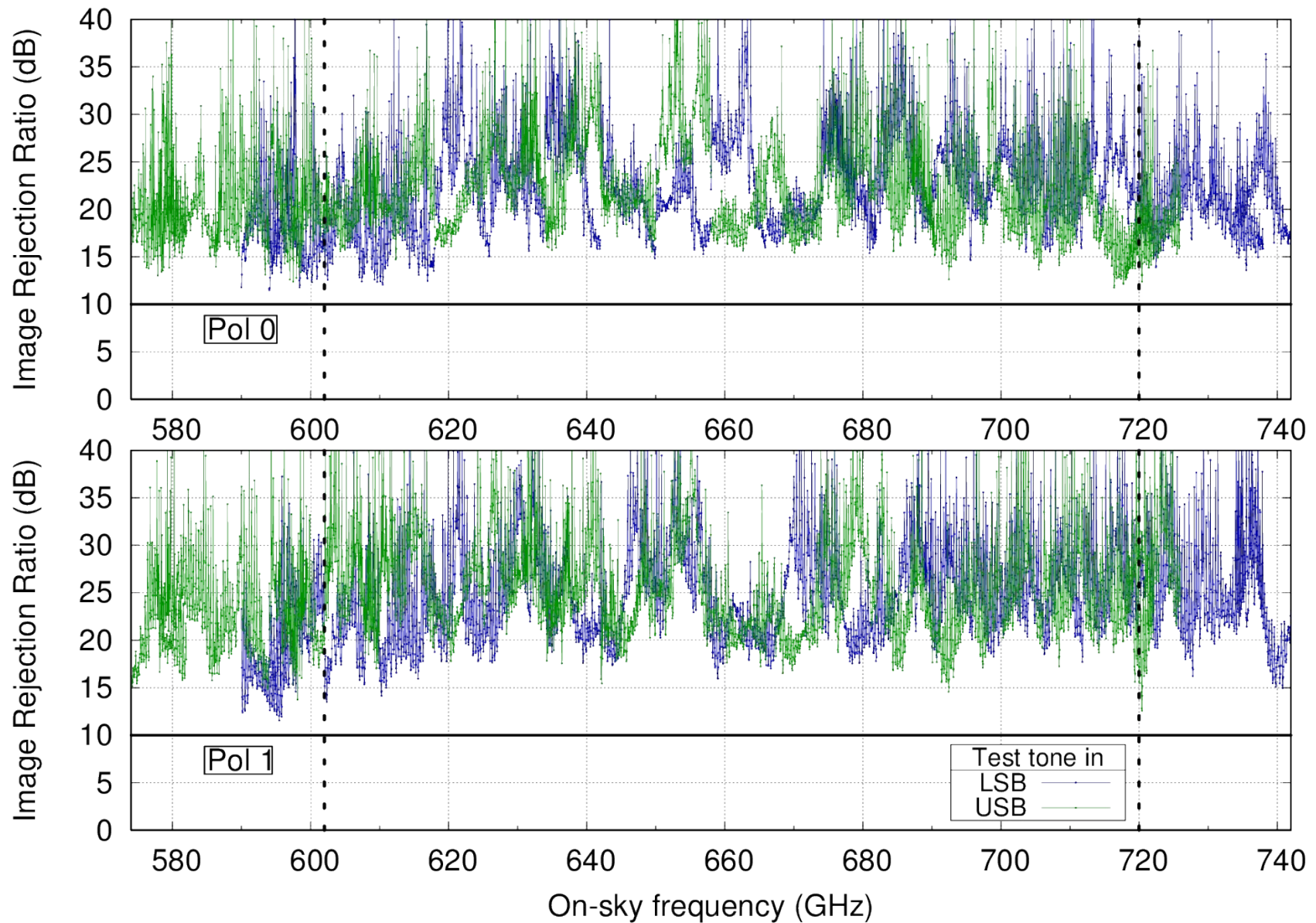
The SEPIA660 cartridge



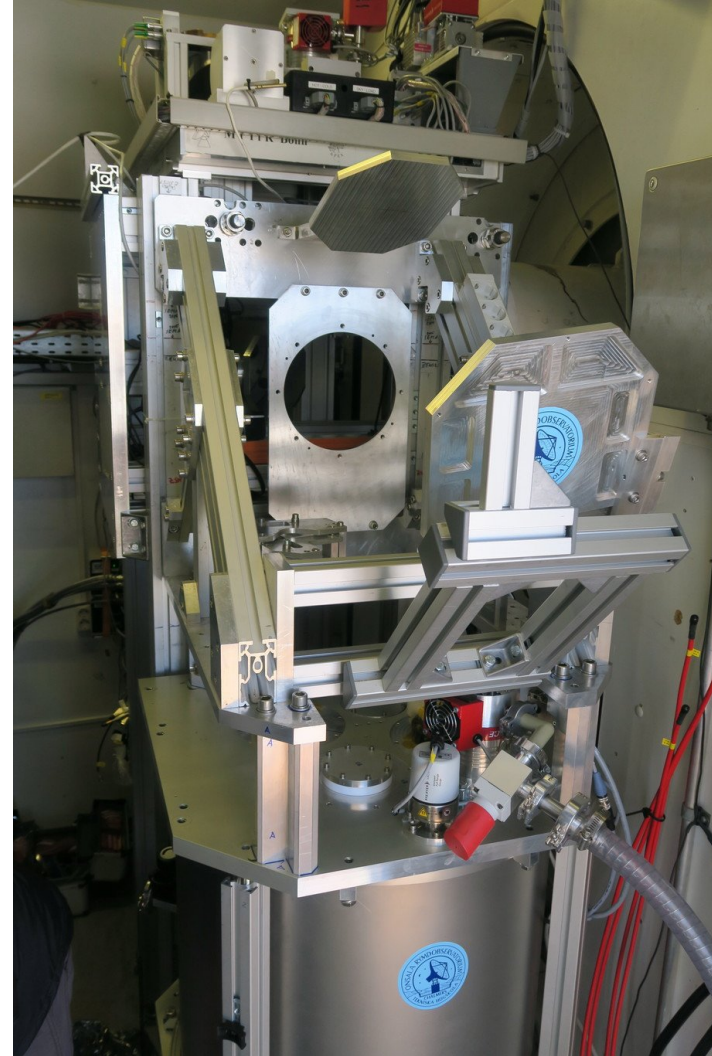
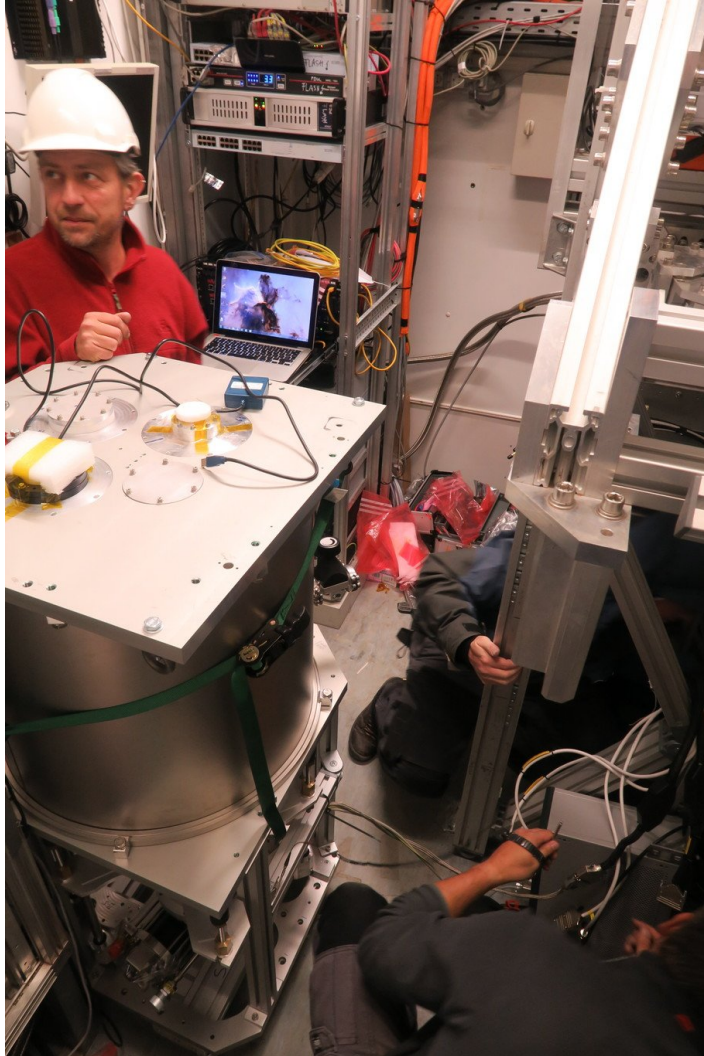
Lab results: noise temperature



Lab results: image rejection



Into SEPIA...



First light – R-Dor

0:0 R-DOR H2Ov1 AP-S60--XF0- O:19-AUG-2018 R:20-AUG-2018
RA: 04:36:45.49 DEC: -62:04:38.5 Eq 2000.0 Rad. 0.0° Offs: -0.3 -0.2
Unknown tau: 0.784 Tsys: 1392. Time: 5.9min El: 36.6
N: 14581 I0: 1823.14 V0: 7.000 Dv: 0.5000 LSR
FO: 658006.000 Df: -1.097 Fi: 646005.214
Bef: 1.0 Fef: 0.95 Gim: 3.1620E-02
Scan: 47001 Subscan: 1

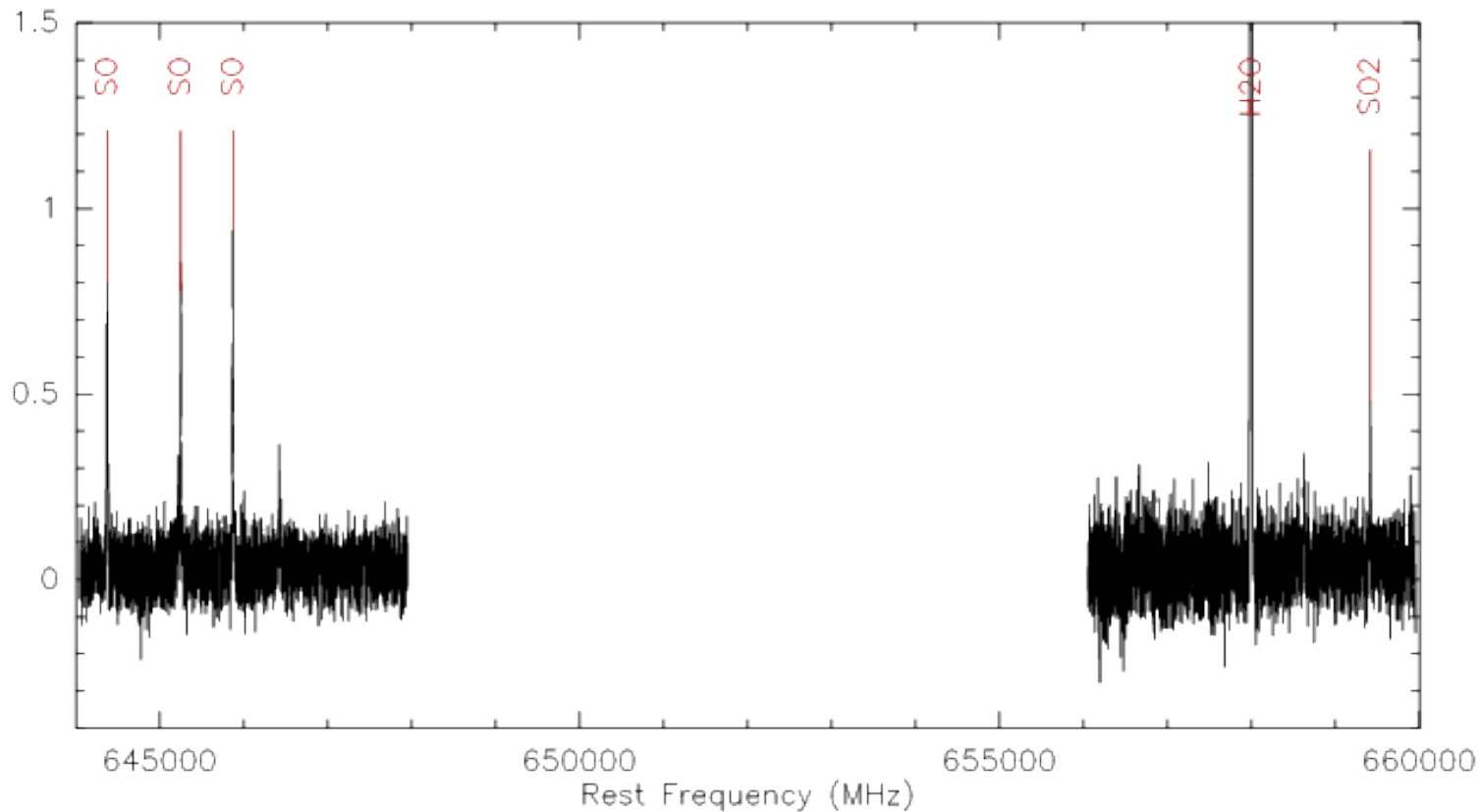


Image rejection - H₂O maser

Source: R-DOR v0: 7.7 km/s dv: 0.5 km/s t: 5.9 min

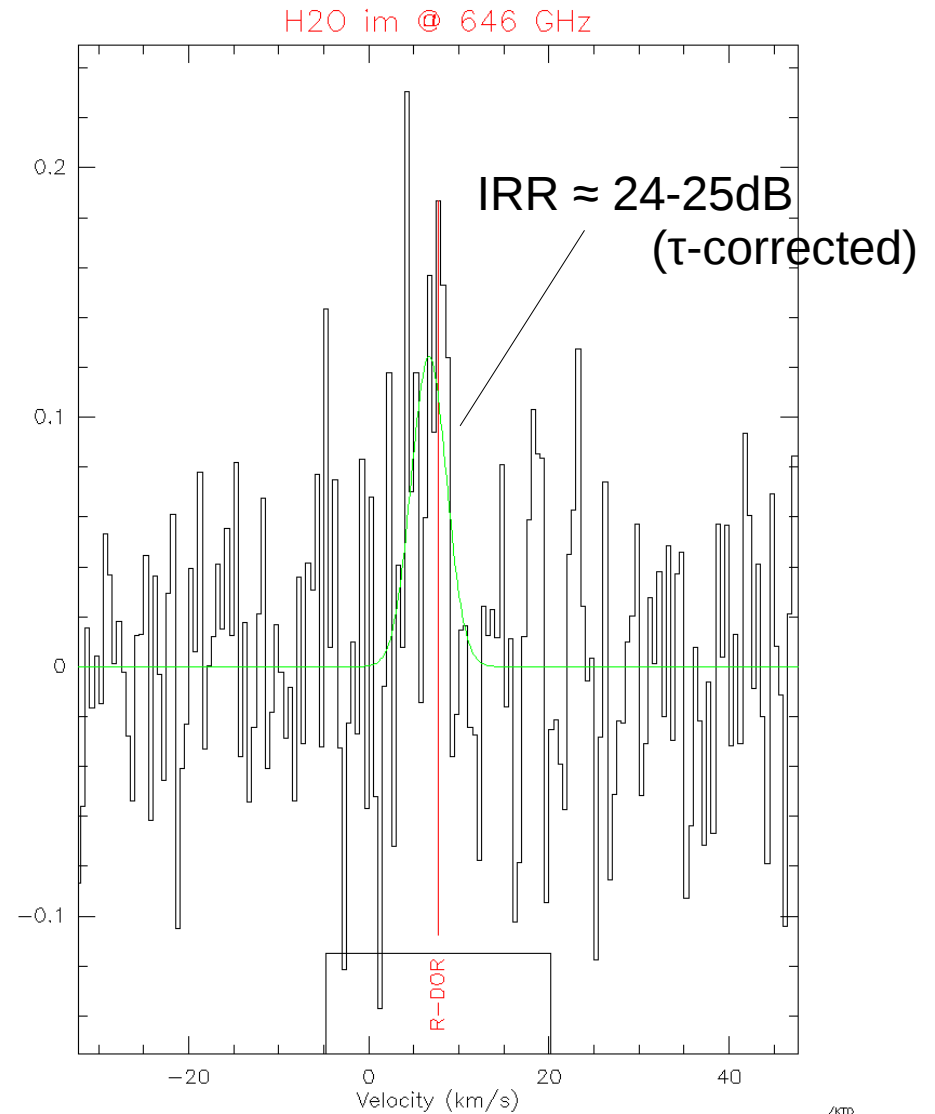
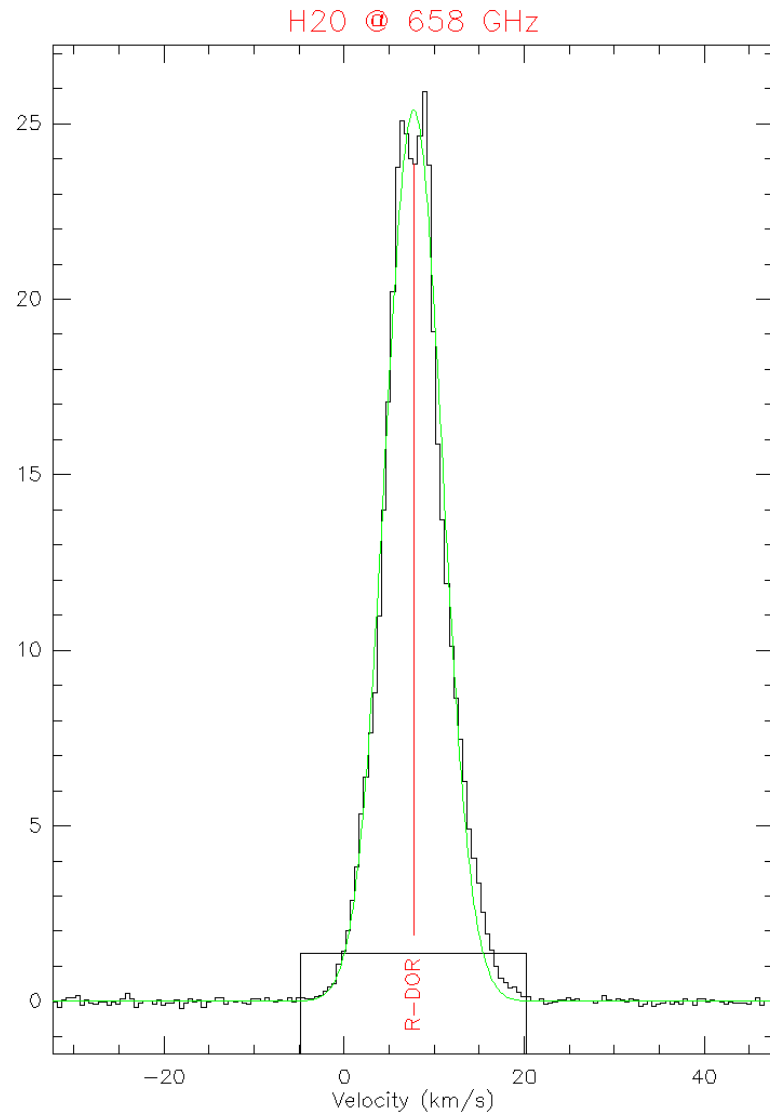
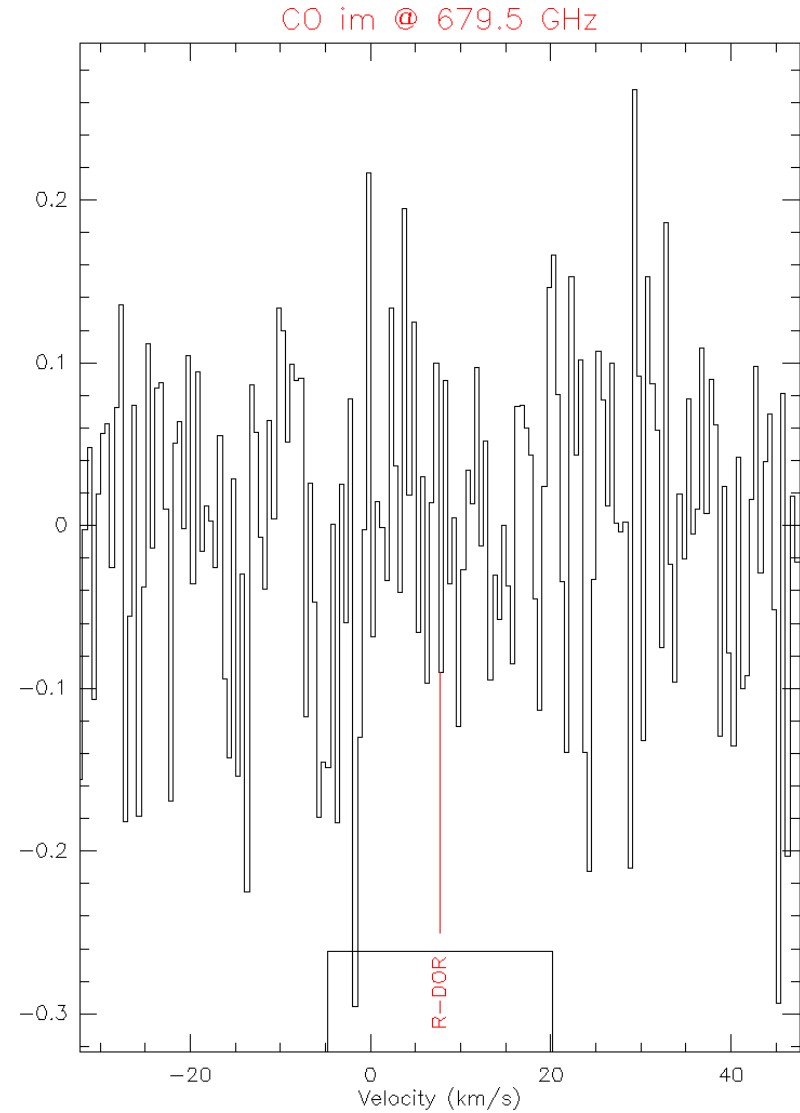
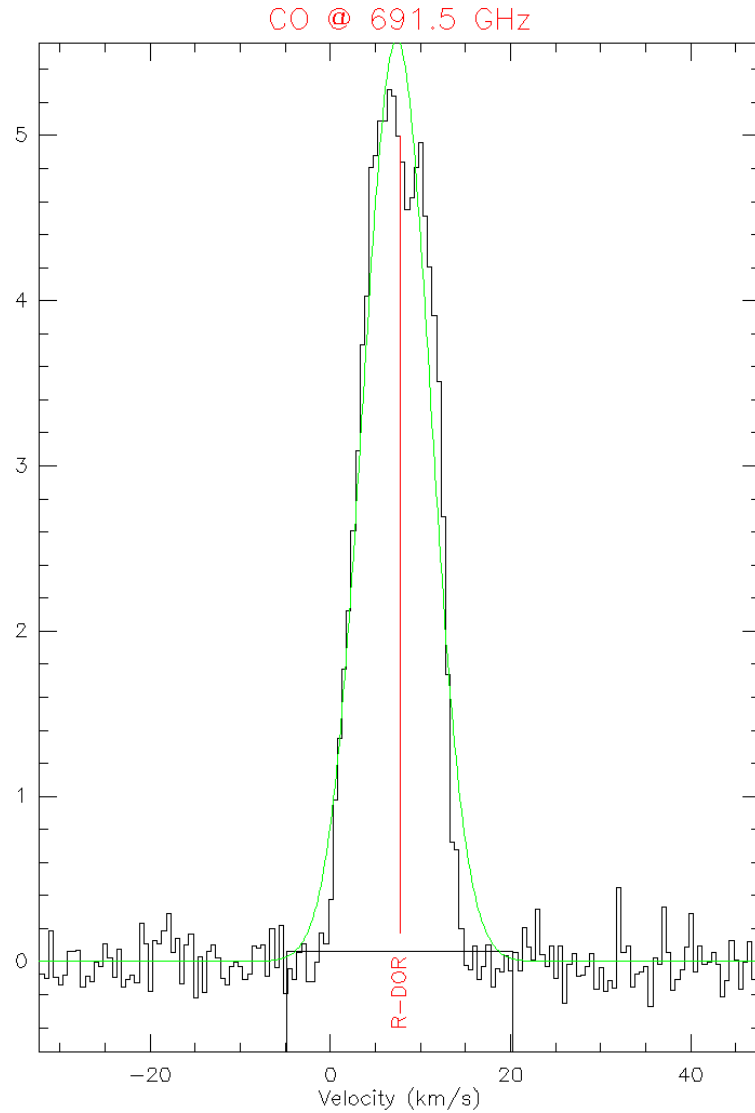


Image rejection - CO 6-5

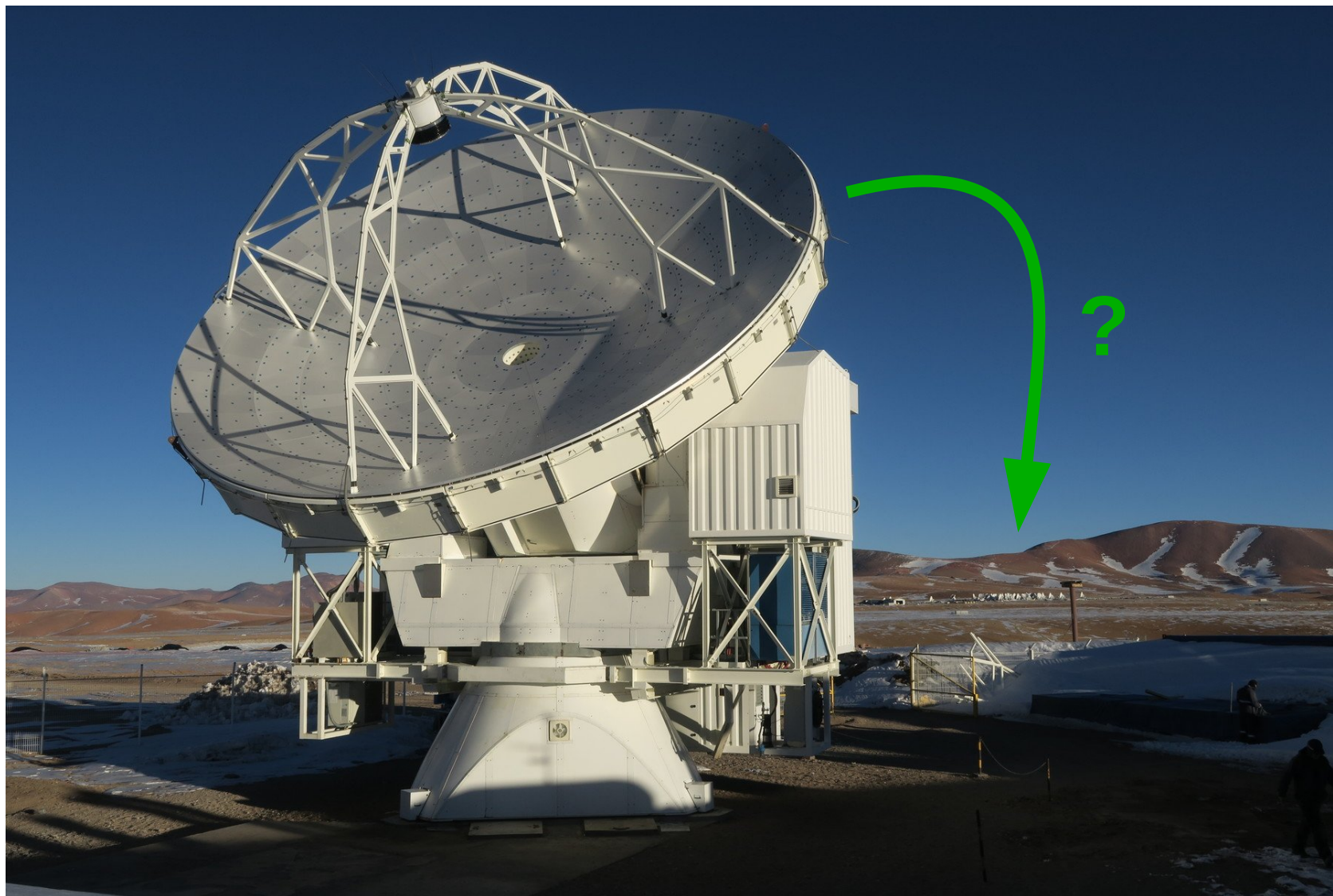
Source: R-DOR v0: 7.7 km/s dv: 0.5 km/s t: 2.9 min



/KTO

For CO $J = 6-5$: no image detectable - IRR better than 24dB

From APEX to ALMA

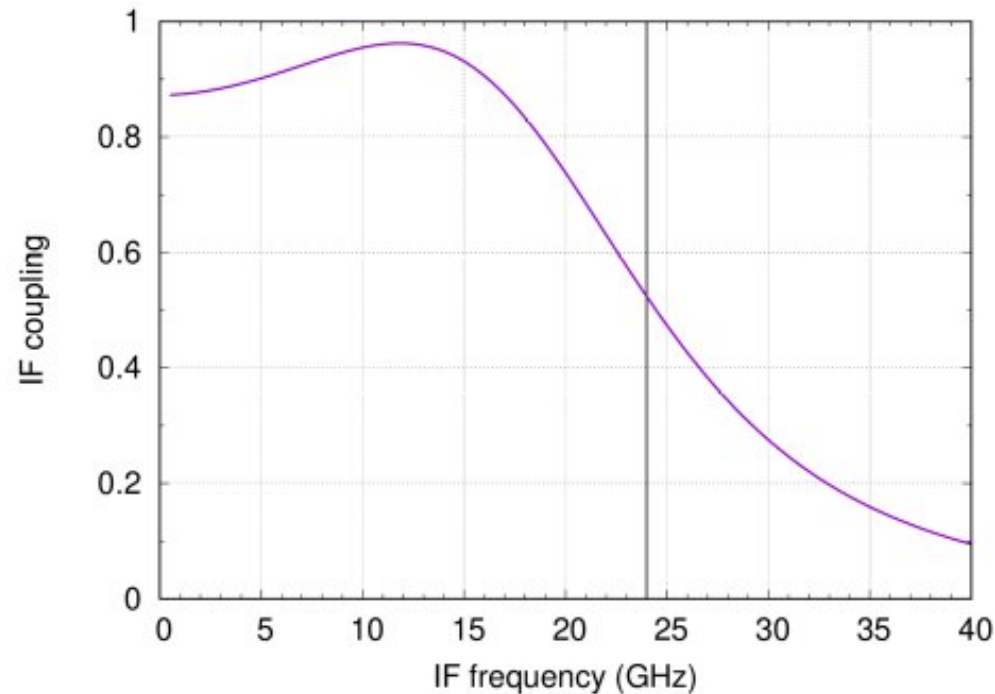


Goals of the study

- 1. Further extension of the IF bandwidth to 4x12 GHz or even more (SEPIA660 has 4x8 GHz)**
2. Extension of RF bandwidth beyond 600-720 GHz
3. The availability of a sufficient number of SIS mixer devices to enable a full upgrade
4. Optionally, the improvement of the optical cross-polarization performance
5. The expected cost for all existing ALMA Band 9 receivers to be upgraded
6. The expected cost for a limited number of pre-production receiver modules
7. The upgrade strategy, especially the possibility to allow continued Band 9 operations during upgrade

Increasing the IF bandwidth

New simulations show that current Band 9 SIS devices may have an IF bandwidth up to 24 GHz



K. Rudakov

Provided that the IF infrastructure can accomodate this, it would mean a total IF coverage of 80 GHz!

Challenges:

- cryogenic IF LNAs
- cryogenic IF hybrids

Conclusions

A dual-pol sideband-separating Band 9 ALMA-class receiver has been demonstrated and commissioned on-sky, with a total IF bandwidth of 32 GHz and image rejection in excess of 20dB on average (better than 15dB everywhere)

RF BW extension to 580-732 GHz was demonstrated.

The technology to implement this in ALMA is ready; expensive components like SIS devices (probably) and LOs (certainly) can be re-used.

Extension of the total IF BW to 48 GHz looks quite feasible, 64 GHz possibly so.

And...

For the Flash receiver (MPIfR) on APEX, we have a 2SB 790-950 GHz mixer with similar performance

→ poster Andrey Khudchenko